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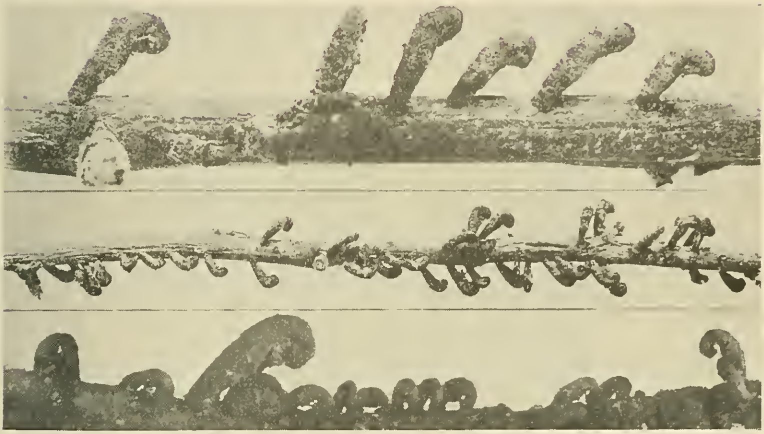
BY EDWIN GOULD



Various enlargements of a group of cocoons on a twig. Bottom figure: winter cocoons and fully-grown cocoon shown for comparison

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by EDWIN GOULD*

FOR SEVERAL YEARS the pistol-case bearer seems to have been increasingly abundant and injurious in the Ranson orchard near Charles Town, W. Va., but the attention of the Experiment Station was not called to the insect until the season of 1927, when the injury began to assume serious proportions. The insect continued to increase during the following seasons and has since become injurious in several other orchards in the vicinity as well as in orchards near Mt. Jackson, Va.

Ordinary orchard-spraying practices failed to control the insect. Even the application of extra strengths of contact insecticides and of arsenate of lead had no appreciable effect. On account of the potential economic importance of the insect to the fruit industry of the region the Experiment Station undertook a study in the spring of 1929. The results herein reported deal mostly with the work done during that season.

Fig. 1.—Typical appearance of affected tree branch

The Ranson orchard was set out in 1900. It is in excellent condition, giving good drainage for both water and air, and is on limestone soil of the Hagerstown series, which lies well. The approximate elevation is 515 feet. The orchard comprises about 85 acres and includes 4290 apple trees, the main varieties being York, Grimes, and Ben Davis. General care has been good; the pruning moderate but the spraying not of the best. Considerable dusting has been done. However, the factors which have contributed to the increase of the case bearer in the orchard are not apparent, for unsprayed trees in the neighborhood do not show any marked degree of infestation.

*These studies on life history and control were made under the direction of L. M. Peairs, entomologist of the Experiment Station.

Small numbers of the case bearer have been found also in other orchards, but evidence to date has not indicated whether the degree of parasitism is higher in lightly infested orchards than in those heavily infested.

The pistol-case bearer is a native insect which was described by Riley *(3)* in 1878 from material collected in Erie county, Pennsylvania. It has since been observed in many localities in the eastern states. A rather serious outbreak occurred in New York State in 1897. Both Lowe *(2)* and Slingerland *(4)* published accounts of the insect. It apparently subsided before doing serious damage and before control measures were thoroughly tested. No account of any important outbreak has been recorded in more recent years until the present one.

Fig. 2.—A typical apple tree in the Ranson orchard, May 28

The case bearer has been observed in orchards in various parts of West Virginia many times but has been considered more curiosity than pest. It is found from Virginia to Kansas and north to Canada.

The pistol-case bearer is a moth of the family *Coleophoridae.* The name given it by Riley was *Coleophora malivorella.* This name is still used, although the insect has also been classed in the genus *Haloptilia.* Related insects are the cherry case bearer, *C. pruniella,* and the cigar case bearer, *C. fletcherella.*

The apple is the principal host plant, but the insect will also feed upon pear, quince, and wild cherry.

The main damage is done in the spring, when the over-wintering larvae feed by eating into the leaf and blossom buds of the apple. One larva may damage several buds by its feeding, which results in ragged foliage and imperfect blossoms and sometimes in the total destruction of the buds. Feeding is continued on the leaves after they unfold and may amount to virtual defoliation of the trees or of branches. Figure 1 shows the typical appearance of a branch which

has been heavily infested. Feeding on the foliage is less important than the bud injury but may continue for a longer period. Occasional feeding on the fruit has been noted, but this seems never to be extensive.

Young larvae of the new brood feed on or in the leaves in late summer, but the damage done at this period is inconsiderable.

As stated, the main damage done by this insect occurs during its spring feeding. The extent of this damage, in an orchard as much infested as was the Ranson orchard in the two or three years before treatment, must be seen to be realized. Figure 2 intimates the conditions throughout the orchard. The branches in the upper portions of the trees had practically no foliage. Their condition suggests early spring rather than the first of June, when the photographs were made.

Obviously the destruction of so much foliage, especially during the early part of the growing season, must have a very injurious effect on the growth of the trees and on the crop for the year. If the condition recurs year after year the value of the orchard must be greatly reduced. This does not take into account the very real and serious injury to fruit resulting from the destruction of the buds in the early feeding of the insects before the leaves have unfolded.

No fruit grower can see an orchard in the condition of this one without being impressed with the fact that the pistol-case bearer is potentially an insect of the first rank as a pest. Not even the codling moth can do the damage which the case bearer, unchecked by natural enemies or by effective spraying, may inflict upon an orchard. The development of control measures is therefore of the utmost interest to all concerned with the apple-growing industry in the Eastern Panhandle.

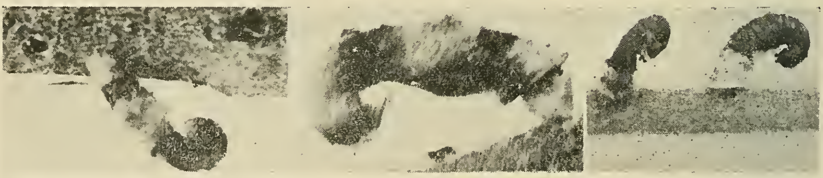

Fig. 3.—Representative views of the growth of the cocoon. Lighter areas show new portions. The pits in the bark of the left-hand figure were made in the process of attaching the cocoons

LIFE HISTORY

The pistol-case bearer passes the winter as a partly-grown larva inside its cocoon, the shape of which suggests its common name. These cocoons, attached to the twigs as shown in the figure on the cover page and in Figure 3, are about one-eighth inch in length and black in color. When the buds first show their green color the case bearers begin to feed. They detach themselves from the twigs and

move by protruding the front part of the body from the cocoon and dragging the cocoon with them to the nearest bud. Here the larva eats into the bud as far as it can reach without leaving its cocoon; it will then move to a second bud and it may injure several buds before feeding on foliage (Fig. 9). Feeding on the leaves is often slight but may be extensive, amounting to the skeletonizing of the leaves. About the last week in May the larvae reach their full growth and crawl back to the twigs, where they attach their cocoons and pupate. Before pupating they enlarge the space in their cocoons by eating into the twigs, through the bark and into the wood, so that little cavities may be found where cocoons have been removed. The larvae then reverse their positions in the cocoons and pupate.

Fig. 4.—On left, recently completed cocoon and pupa removed from it. On right, partly grown larvae removed from cocoons

It should be noted that during the spring growth the cocoon is enlarged as the insect grows, until the cocoon of the fully-grown larva in many instances is more than one-fourth inch in length. Enlargement is accomplished by adding to the open end of the cocoon, the new portions at first being white in color, and also by enlarging the diameter with material apparently built on the edges of a slit along the concave side of the cocoon. Figures 7 and 8 give some details of this process.

In 1929 the first pupa (Fig. 4) was noted on May 22, but the peak of the pupation period did not occur until June 6. As stated, the first preliminary to pupation is reversal of the larva in the cocoon. The pupae then gradually change in color from the original light yellowish brown to a dark brown. A thin pupa case is formed through which the gradual formation of the appendages can be distinctly seen. Fifteen to seventeen days are required for the transformation to the adult insect. The adults emerge through a slit formed in the construction of the cocoon as described on page 7.

The first adults were noted, in the season of 1929, on June 8, the peak of the emergence coming between the 19th and the 21st. The moths are steel-gray in color, bearing narrow, lanceolate wings with fringes of long hair on the margins. The wing expanse is about one-half inch. The moths are rather active and when disturbed will dart

about and hide on the under surface of a leaf, but seem never to fly far. They seem to fly normally at night and remain concealed in the day time. How far they may spread by natural flight has not been determined.

The sexes differ only slightly in appearance (Fig. 5). Females are larger and lighter in color than the males, having also numerous distinguishing white scales on the wings near their bases. Both sexes have legs and antennae marked by alternating rings of light and dark scales. The hind legs have two pairs of spines near their

Fig. 5.—Adult moths: left, male; right, female
AFTER SLINGERLAND

distal end; the middle legs have one pair and the front legs are spineless.

The first eggs were noted on June 10 (1929). The peak of the oviposition period was between the 20th and the 23rd of June. More than 92 percent of the eggs was laid on the upper side of the leaves, as the smooth waxy surface seems to be preferred to the less smooth lower surface. In confinement the moth will oviposit on glass, wood, or other substances, but such eggs were not observed to hatch in any instance. Eggs laid by moths in cages occurred on the upper surface in 1133 cases and on the lower surface in 184 cases, showing a slightly higher percentage on the lower surface than was the case under natural conditions. Eggs are placed promiscuously over the leaves, one in a place. They are about one half millimeter in diameter, nearly as high as they are wide, and light brown or clay in color.

In spite of their small size the eggs are rather easily seen, appearing somewhat like little specks of clay scattered over the leaf. When magnified, the eggs are seen to be scalloped on the margin, with converging ridges which join an apical ring near the top of the egg. The central portion of the top is somewhat sunken and the whole suggests a minute "sample cake" baked in a scalloped pan (Fig. 6). This visible surface is, of course, only the shell or protective covering for the exposed surface of the egg and does not completely surround the egg proper, the lower surface of the egg resting directly on the leaf. The shell may therefore be lifted off the egg without apparent injury to the egg; but such eggs do not hatch. The egg proper is a gelatinous, light-brown mass. After the eggs hatch, the shells remain attached to the leaves and turn white. For

this reason they are more readily visible. Later they become detached.

The eggs hatch in from ten to twelve days. The newly-hatched larvae are brownish in color with a conspicuous dark shield on the dorsum of the prothorax and a dark spot on the dorsum of the mesothorax. The dorsal side of the metathorax is similar to that of the abdominal segments except that it becomes slightly darker as the insect grows older. Upon hatching, the insects eat their way directly into the tissue of the leaf from beneath the eggshell without being exposed. Here they feed as miners for two or three days, then emerge on the under surface of the leaf with their cocoons already formed so that they are protected to a degree. This emergence is the first indication that the eggs have hatched, for the eggs change slowly in appearance. The emergence may be at a point some distance from the location of the egg and is always on the under surface, regardless of the location of the egg.

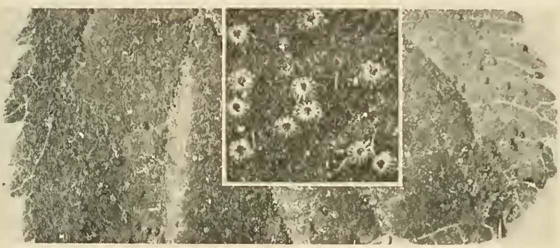

Fig. 6.—Eggs of the pistol-case bearer on apple leaf. Insert, close-up view of eggshells

The first indication of the emergence of the larva is a small spot, of lighter green color than the surrounding tissue, which is being pushed outward in the formation of the first cocoons by the larvae. The first step in this construction seems to be the chewing up of part of the leaf tissue into small granules. These are cemented together into a conical, tube-like affair, protruded from the opening in the leaf, and are enlarged to cover the entire insect as it emerges. During the process the caterpillars look as though they might have been rolled in light green dust. The cocoon is next lined with a mixture of silk and some kind of cementing material, and the leaf particles gradually turn brown and crumble off. For about one month the cases remain open along the ventral edge. The case is enlarged by building upon the anterior edge, the two edges of the ventral slit being held together during the process by a slight lining of silk, only a short portion near the posterior end being left entirely open. This serves later as the place of exit for the moth.

During the spring growth of the larva a flange-like extension is formed along the ventral margin by material pushed out through

this opening. This is shown in Figures 7 and 8. The cocoon showing the first spring addition and the slit is well shown also in Figure 8. After the caterpillars first emerge from the leaf they continue feeding until about half grown, then migrate to the twigs about September 20 to attach themselves for the winter. (See figure on cover page.) This feeding is almost entirely inside the leaf. The insects gnaw small holes through the surface, eat into the leaf as far as they can reach without leaving their cocoons, then change their location and repeat the process (Fig. 9). Whether they actually swallow the superficial tissue has not been determined. In any event it is apparent that they would get very little of any poison which might be on the surface.

Fig. 7.—Cocoons in various stages; a larva is protruding in characteristic fashion from one. Note exit hole of parasite in middle figure

Fig. 8.—Nearly completed cocoon; the slit in the ventral surface serves later for the escape of the moth

The caterpillars normally never abandon their cases. If removed from them they may construct new ones. These resemble the cocoons of the cigar-case bearer more than the usual cases of the pistol-case bearer. The caterpillars are able to spin new cocoons up to within a few days of pupation.

When detached from the leaves or twigs they may spin silken threads by which they are suspended so that they do not drop to the ground.

Early hibernation apparently can be induced by reducing the flow of sap to the leaves.

The hibernating cocoons are firmly attached to the twigs; often part of the bark will be pulled off the twig when an attempt is made to remove the cocoon. The larvae become active in the cocoons some time before loosening their hold on the twigs to seek food. They then make their way to the nearest buds and begin feeding, continuing, as already described, until time for pupation, when they reattach themselves to the twigs, spin a silken pad or mat over the

open end of the cocoon in the cavity or depression formed in the twig, and, shortly afterward, pupate.

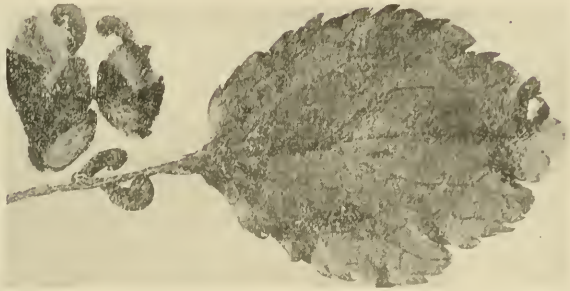

Fig. 9.—Larvae attached to petiole; others feeding on surface of leaf. Insert, case bearers feeding on buds

NATURAL CONTROL

The percentage of winter mortality, while not definitely established, seems not to be high as compared with that of many other species of insects. Some destruction of the cocoons by birds has been noted, but the importance of this has not been determined. The following species of parasites* have been reared, with percentage of parasitism and relative abundance of the different species not yet certain:

Hyposoter annulipes (Cress).
Hemiteles gracilariae (Ashm).
H. tenellus (Say)
Microbracon pygmaeus Prov.
Meteorus vulgaris Cress.
Macrocentrus sp. nov. (Muesebeck det.)
Rhoptrocentrus sp. nov. (det. Muesebeck)
Bassus coleophorae Rohw.
Monodontomerus (?) sp. nov.
Coleopisthia (Trineptis) hemerocampae Gir.
Habroeytus sp. nov. (or possibly *phycidis).*

The species last named seems to be the most important of the parasites of the pistol-case bearer. An unnamed species from this genus has been recorded from the cigar case bearer (Hammar *(1)*). Gahan expresses the opinion that the *Monodontomerus* is a secondary parasite and states that some of the others, the *Rhoptrocentrus* for example, were not ordinarily parasitic on moths. The conditions were such as to leave no doubt that all these issued from cocoons of the case bearer, since they were reared from collections of cocoons detached from the twigs.

*The parasites were identified by Mr. A. B. Gahan of the United States National Museum, Washington, D. C., or through the kindness of Mr. Gahan by Mr. R. A. Cushman of the Museum; and by Mr. C. F. W. Muesebeck.

Early suggestions assumed that the insect could be controlled by increasing the concentration of the poisons applied early in the season and by more thorough work at this time. Increased concentration of oil sprays and of nicotine in the spring sprays was also suggested. Tests of these materials failed to show a satisfactory degree of control, while observations of the habits of the insect indicated control by poisons as unlikely, since the main feeding in spring as well as in summer was inside the leaves or inside the buds, where poisons would be avoided. It seemed possible also that heavy applications of arsenate of lead in the spring might defeat their purpose inasmuch as the small insect, even when feeding on the surface of the leaf, might tend to avoid that portion on which the foreign matter occurred. Since the feeding is slow and the growth of the foliage at this period rapid, such choice would be entirely possible and might account for the failure of even six pounds of arsenate to 100 gal. of spray to give control. The contact insecticides tested in the spring were also practically useless on account of the impervious nature of the cocoon.

Failure to control in the spring together with observations on the summer development of the insect suggested that the most vulnerable period in the life of the insect might be when the larvae were newly emerged from the leaves. Since emergency treatment of the orchard under observation during the season of 1929 was necessary to prevent extensive loss the following season, it was necessary to determine quickly what material might be used for summer treatment and to apply this before the larvae had passed the stage where the treatment might be effective.

Several thousand of the insects were collected at pupation and brought into the laboratory to hasten development. As soon as the moth emerged, several caged trees were infested as heavily as possible. The young larvae thus secured were used for preliminary tests of materials. In these first dipping tests various concentrations of all the available standard insecticides were used, both stomach poisons and contact poisons. From about 40 such materials the most promising were applied in the orchard as sprays in the usual fashion. Among the materials tested may be mentioned arsenate of lead, Paris green, Bowker's green arsenate, pyrethrum extracts. neococotine, Bordeaux mixture, nicotine and penetrol, and the combination of penetrol with nicotine and other materials. Of the materials tested the best results were obtained from a combination of 1 part nicotine to 800 parts of water with penetrol at ½ percent concentration. As high as 100% kill was obtained in dipping tests with this combination. Arrangements accordingly were made to treat the orchard with this material.

All the available evidence indicated that prompt application of the spray material was desirable, as it seemed certain that, the younger the larvae were, the more susceptible they would be to the action of a contact spray. For this reason it was arranged to em-

ploy several spray outfits, volunteered from neighboring orchards. An attempt was made to select from those offered the ones which seemed most efficient, but considerable variation in effectiveness was evident.

The spray application was begun on July 17 but on account of weather conditions was not completed until the 27th. More than 67,000 gal. of material, or over 15 gal. per tree, was applied and even this quantity proved too little rather than too much.

Considerable variation was noted in the results from the different spray outfits. This probably was due in part to the outfits and in part to the operators, although every effort was made to have the work done as thoroughly as possible. The best outfit gave an average kill of 88.24%, while the poorest one showed only 75.61% kill. The two outfits showing poorest results were of the same make, indicating that the fault was with the sprayer rather than with the operators.

The average kill from all outfits, based on counts of more than 12,000 insects, was 78.92%. Kill on the outer portions of the trees was always higher than that on the inner portions and in the extreme tops. It seems probable that the percentage of kill represents the efficiency of the sprayers rather than that of the material, for kills of more than 90% were recorded on the outside of some trees, and the preliminary tests indicated an efficiency near 100% for the material under optimum conditions.

Observations in the orchard later in the season indicated that there might be some residual effect from the spraying and that the actual kill may have been even greater than the counts showed. The recovery of the orchard following the spraying was marked. New foliage developed, and the crop harvested was far above early season expectations, although far from what might have been expected had the case bearer not done its work. In the following spring there was considerable infestation, but damage did not approach in severity that of the previous season; in fact it was scarcely as pronounced as that in other orchards which had not received the special treatment but which had not shown commercial injury the year before.

The general conclusions are therefore that the 78% kill constituted a reasonably effective treatment and that this, along with the work of the natural enemies, will hold the insect in check to such an extent that commercial damage need not be feared.

The objections to the treatment developed are its expense and the fact that it involves an extra spray operation not now included in the program. Future control work will seek to discover a material which is effective when applied in the early season or along with some one of the regular sprays and which employs a material less expensive than the combination of nicotine and penetrol. For a dormant treatment it seems that a contact spray with a greater power of penetration than any now in common use will be necessary. A stomach poison to kill the larvae early in their spring feeding is a possibility but scarcely a probability, since so much injury is done

by boring into the buds, where poison can not be effective. A little later, toward the end of the feeding period, stomach poisons might well be effective if of such a nature that the insects would not avoid them and would not seek unsprayed surfaces on which to feed.

Investigations on control of the insect will continue. It seems well worth while to continue the search for better sprays until a method of control is established which shall be available at no considerable extra cost to the grower, yet enable him to prevent the accumulation of this insect in his orchard. When such treatment becomes available it should be incorporated in the spray program as a preventive treatment, so that extra treatments to prevent commercial damage will never become necessary.

For the present it may be said that a greater degree of thoroughness in the application of the sprays constituting the program now in use should tend to keep down infestation. It is known that some of the insects are killed by arsenicals during the spring feeding; if the foliage is more completely covered by more careful spraying, the percentage so killed is bound to be larger, and it is likely that in orchards where the best possible spraying is done, the insect will not increase.

SUMMARY

The pistol-case bearer is an insect which has increased in abundance during recent years to such an extent in certain orchards in the Eastern Panhandle of West Virginia that it may be said to rival the codling-moth in destructiveness. It has been found very difficult of control; so far the usual spray program, even with modifications of the materials used, has failed.

A degree of control which probably will at least prevent the increase of the insect in abundance has been secured by the use of a combination of nicotine sulphate at one part to 800 parts water with one-half percent penetrol, applied just after the hatching of the eggs in July. The utmost thoroughness in the application of this material has been shown to be necessary if a satisfactory degree of control is to be obtained.

It is recommended that special sprays to keep down the numbers of the insects be applied in orchards where it seems to be increasing, although not yet present in destructive numbers.

Further work in the development of new control methods and materials is in progress.

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